



Food availability and trophic needs of *Peltodoris atromaculata* (Mollusca: Doridacea)

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KEY WORDS: *Peltodoris atromaculata*, trophic activity, energy balance.

ABSTRACT *Peltodoris atromaculata* (Bergh, 1880), a Mediterranean doridacean mollusc (Nudibranchia: Doridacea) very common in the pre-coralligenous and coralligenous communities, feeds almost exclusively upon *Petrosia ficiformis*, a diffuse demosponge hosting, in its symbiocortex, a dense cyanobacteria population. Considering its strong monophagy, this mollusc seems to be adequate for studying energy fluxes between benthic filter-feeders and carnivores and for verifying trophic needs and energy balance in a monophagous predator. Laboratory experiments (trophic activity, calorimetry) and *in situ* observations have allowed to evaluate the trophic activity of this species (a 30 mm long mollusc grazes, daily, a surface of about 50 mm² of *Petrosia*) and to calculate average energetic value of its prey (symbiocortex: 6335.4 cal/g AFDW; medulla: 6219.0 cal/g AFDW). As the water content of the sponge is about 73 % and its ash content is about 15 % of WW, the edible organic matter is about 11-12 % of the whole sponge tissue. Considering these values, the energetic value of 1 mm³ of *Petrosia* (being its specific weight 1.2 0.11 g/mm³) is 0.9 cal. During the whole life cycle (24 months) of *Peltodoris*, considering that it can reach a maximum length of 100 mm, it needs about 500 cm² of *Petrosia*, (equivalent to 46000 cal), of which about 14000 are lost as heat.

RIASSUNTO *Peltodoris atromaculata* (Bergh, 1880), mollusco doridaceo (Nudibranchia: Doridacea), molto comune nelle comunità mediterranee del coralligeno e pre-coralligeno, si nutre in modo quasi esclusivo di *Petrosia ficiformis*, una demospongia assai diffusa che ospita, nella propria symbiocortex, una densa popolazione di cianobatteri. Grazie alla sua stretta monofagia, questo mollusco sembra adeguato per effettuare studi sui flussi energetici tra organismi bentonici sospensivori e carnivori e per analizzare le necessità trofiche ed il bilancio energetico in un predatore monofago. Esperimenti condotti in laboratorio (attività alimentare, calorimetria) ed osservazioni effettuate *in situ* hanno permesso di valutare l'attività trofica di questa specie (un individuo lungo 30 mm si nutre, quotidianamente, di una superficie di circa 50 mm² di *Petrosia*) e di calcolare il valore energetico medio della sua preda (symbiocortex: 6335.4 cal/g AFDW; medulla: 6219.0 cal/g AFDW). Dal momento che il contenuto in acqua della spugna si aggira intorno al 73 % e quello delle ceneri è pari a circa il 15 % del WW, la frazione organica edule è pari a circa l'11-12 % del peso totale della spugna. Considerando tali valori, il valore energetico di 1 mm³ di *Petrosia* (il cui peso specifico è 1.2 0.11 g/mm³) è pari a 0.9 cal. Durante l'intero ciclo vitale di *Peltodoris* (24 mesi), considerando che può raggiungere una lunghezza massima di 100 mm, questo nudibranco necessita di circa 500 cm² di *Petrosia* (equivalenti a 46000 cal), delle quali circa 14000 sono consumate nella respirazione.

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INTRODUCTION

Nudibranch molluscs are considered stenophagous predators (TODD, 1981), but indeed just few species show a real monophagy, as generally the predator chooses on a bulk of preys, often taxonomically allied. This could bias the evaluation of the trophic needs of a supposed monophagous species, being the food availability wider and diversified than supposed.

Differently, *Peltodoris atromaculata* Bergh 1880, a Mediterranean doridacean mollusc (Nudibranchia: Doridacea), very common in the pre-coralligenous and coralligenous communities (HAEFELFINGER, 1961; AVILA, 1996), feeds almost exclusively upon *Petrosia ficiformis* (Poiret, 1789), a widespread Mediterranean demosponge, hosting in its cortex a dense cyanobacteria population, belonging to the species *Aphanocapsa feldmanni* (SARÀ & LIACI, 1964; SARÀ *et al.*, 1998). Rarely, young specimens of *Peltodoris* were observed to feed on the sponge *Reniera fulva* Topsent, 1893 (CATTANEO-VIETTI *et al.*, 1993).

Behavioural tests and biochemical analyses have underlined its feeding preference: CASTIELLO *et al.* (1980) showed the ability of the mollusc to absorb and retain high molecular weight polyacetylenes (petroformynes) from its prey, often showing a strong cytotoxic effect and used as bioactive chemicals against predation.

Consequently, considering the strong monophagy of this mollusc, the *Peltodoris* vs *Petrosia* predation model seems to be adequate for studying energy fluxes between benthic filter-feeders (the sponge) and carnivores (the mollusc). Moreover, it could be useful to evaluate the trophic needs and the energy balance in a marine monophagous predator.

MATERIAL AND METHODS

In order to measure the amount of sponge daily eaten, 16 specimens of *Peltodoris atromaculata* (20 to 80 mm in length) were collected from several stations placed along the Portofino Promontory (Ligurian Sea) between February and September 1997. Nudibranchs were taken to the laboratory and placed in holding chambers (1 litre plastic containers with screened sides to allow water circulation) inside aquaria with flowing, filtered sea-water at ambient temperature (16° C). In each container a specimen of *Petrosia ficiformis*, collected in the same site, was placed. Every week, sponges were substituted and the eaten surface was measured using a camera lucida connected with a PC.

In order to evaluate the energetic content of *Petrosia* and *Peltodoris*, additional 8 specimens were collected, at different depths, in April and December 1997. The caloric content of

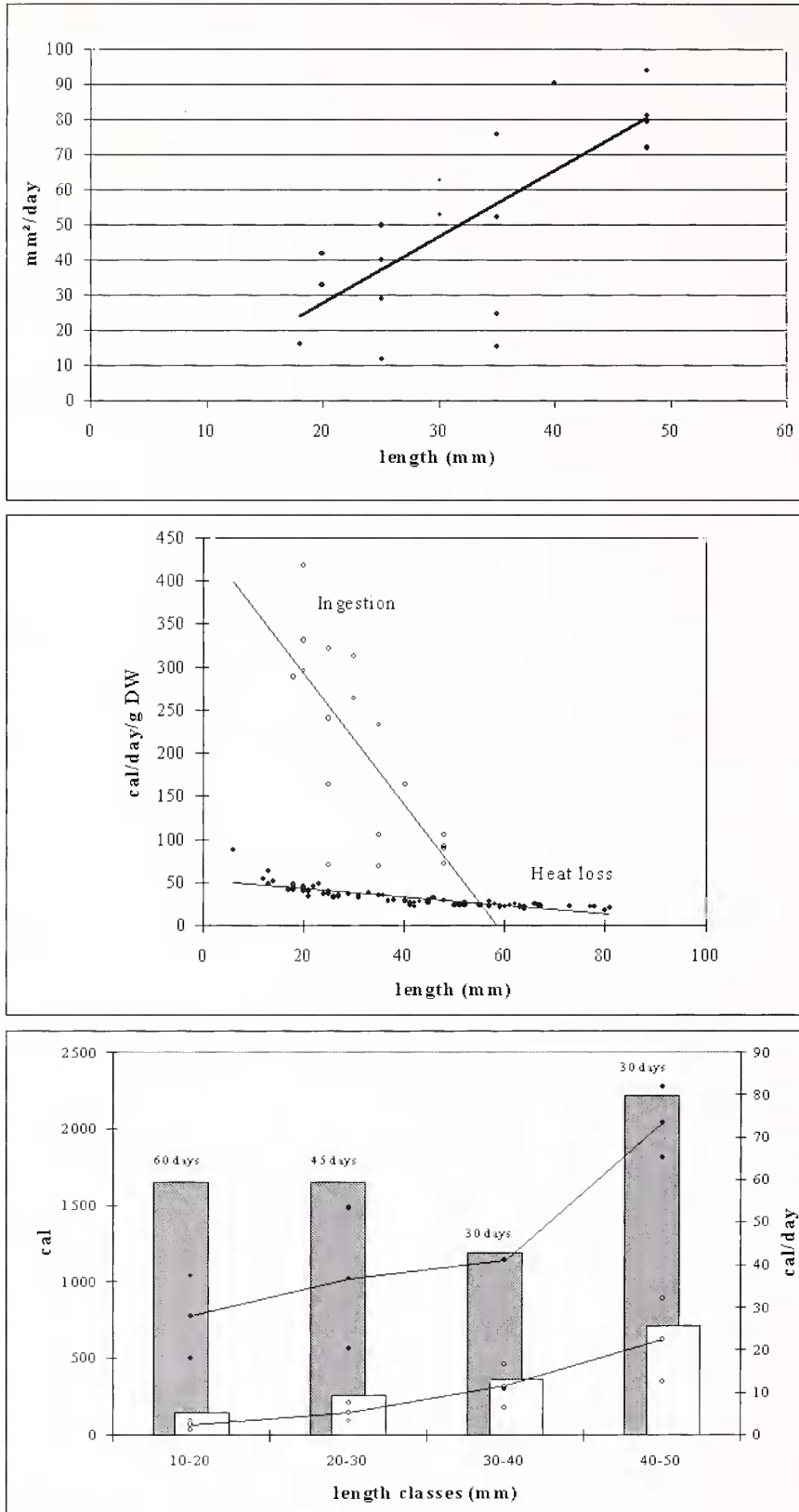


Fig. 1: Daily eaten surface of the sponge *Petrosia ficiformis* by different sized *Peltodoris atromaculata*. Fitting linear correlation: $Y = 1.89 X - 10.29$; $R^2 = 0.56$; $df = 16$; $p < 0.001$.

Fig. 2: Weight specific daily ingestion and heat loss rates in different sized *Peltodoris atromaculata*. Ingestion: $Y = -7.61 X + 444.81$; $R^2 = 0.54$; $df = 16$; $p < 0.001$. Heat loss: $Y = -0.51 X + 53.06$; $R^2 = 0.71$; $df = 79$; $p < 0.001$.

Fig. 3: Total ingestion (grey histograms) and heat loss (white histograms) in calories by *Peltodoris atromaculata* growing from each size class to the next one (days spent reported on top of histograms). Daily ingestion (black dots) and daily heat loss (white dots), reported in the linear graphics (avg $\pm$ std).



Table 1 *Petrosia ficiformis*: Calorific content (cal/g AFDW) of cortex and medulla (avg ± std) and chl-*a* content of the cortex (mg/cm2) measured in specimens collected at different depths

Depth (m)	Cortex (n = 8)	Medulla (n = 8)	chl- <i>a</i> content
5	6609.8 ± 452.2	6484.0 ± 359.9	42
10	6184.1 ± 789.7	6101.4 ± 656.0	30
20	6244.9 ± 697.3	5781.0 ± 361.7	31
30	6278.1 ± 568.8	6762.9 ± 362.6	17
40	6665.5 ± 505.0	6798.1 ± 363.1	4
50	6138.4 ± 328.2	6004.6 ± 323.1	
Cave	6227.2 ± 266.4	5601.2 ± 137.4	
Avg	6335.4 ± 515.4	6219.0 ± 471.7	

Table 2 Energetic content and ash % in different mollusc species. All data, except present data for *Peltodoris atromaculata*, are from PAINE, 1964

Species	Ash DW %	cal/g AFDW
<i>Peltodoris atromaculata</i>	34	5644
<i>Aegires albopunctatus</i>	43	5309
<i>Polycera atra</i>	28	5680
<i>Triopha maculata</i>	27	5641
<i>Acanthodoris rhodoceras</i>	41	5439
<i>Hopkinsia rosacea</i>	43	6007
<i>Dendrodoris albopunctata</i>	40	5158
<i>Dirona picta</i>	41	6675
<i>Flabellina iodinea</i>	30	4943
<i>Hermisenda crassicornis</i>	28	6446
<i>Bulla gouldiana</i> (without shell)	25	6352
<i>Haminoea virescens</i> (without shell)	27	5335
<i>Navanax inermis</i>	36	5992
<i>Aglaja diomedea</i>	27	5555

these specimens was estimated using a Phillipson microbomb: samples were washed, dry frozen and sifted to obtain a powder as fine as possible, prepared as pellets (0.02 g DW) and burned (PHILLIPSON, 1964; PRUS, 1975). A known amount of benzoic acid was added to the pellets to act as a binding agent and used as a standard. Ash weight (ADW) percent content of sponge and mollusc tissues was obtained by placing dried samples in a muffle at 500C for 4 h. The edible matter percent of *Petrosia* was estimated considering the ratio between the AFDW (DW-ADW) and the total WW.

The estimation of the basal metabolism of *Peltodoris* was performed using the formula proposed by CRISP (1971):

Q (cal/day) = A wb

where:
A = 1.05
b = 0.8
w = g DW
at T = 15° C

RESULTS

The energetic content of the tissues of the mollusc, measured as cal/g AFDW in 8 specimens, is 4786 ± 227 in the foot, 5687 ± 579 in the mantle 6458 ± 241 in the viscera, without significant differences. The average ash content of mollusc tissues is about 33.9 9.3 %. The foot and the mantle show quite similar values (39.5 ± 3.8 % and 39.3 ± 1.0 % respectively), while vis-



cera show a lower value (19.3 ± 0.2 %), due to the absence of calcareous spicules in these tissues (CATTANEO-VIETTI *et al.*, 1993, 1995).

The data on the energetic content of the symbiocortex and the medulla of *Petrosia ficiformis* collected at two different depths are reported in Table 1. The average energetic value of the symbiocortex is 6335.4 cal/g AFDW, while that of the medulla is 6219.0 cal/g AFDW. The water and ash content percentages are 73.5 4.5 % and 14.7 3.5 %, respectively. Consequently the edible organic matter is 11.74 %. Considering these values and its specific weight (1.2 ± 0.11 g/cm³), the energetic value of 1 mm³ of *Petrosia* is 0.9 cal.

Figure 1 shows the trends of the trophic activity of *Peltodoris* in aquaria, on the basis of the daily grazed surface by each specimen. The depth of this area is about 1 mm. On average, a specimen of middle size (30 mm long) grazes, daily, a surface of about 50 mm² of *Petrosia*.

The weight specific eaten surface, calculated as cal/day/g is, obviously, higher in smaller specimens, which consume, as DW, three times more sponge tissues than larger ones, while the weight specific heat loss does not vary significant according to the mollusc size (Fig. 2).

The global energy balance of *Peltodoris atromaculata*, in accordance with the growth rate proposed by AVILA (1996), has been summarised in Figure 3. During 165 days, the time needed to reach a length of 40-50 mm, this mollusc grazes about 74 cm² of *Petrosia*, corresponding to 6700 cal and consumes about 1475 cal as heat loss.

DISCUSSION AND CONCLUSIONS

From an energetically point of view, the study of the trophic relationship between the nudibranch *Peltodoris atromaculata* and its prey, the sponge *Petrosia ficiformis*, has allowed to evaluate the trophic needs and the energy balance of the mollusc.

In *P. atromaculata*, the energetic contents of the mantle and the foot are similar, even if the mantle one is lightly higher, because of the presence of insoluble proteins due to a larger amount of connective tissue. The viscera show, as expected, the highest values, due to the high lipid contents in the hepatopancreas and reproductive systems. The energetic content of the mollusc is in accordance with the values reported by PAINE (1964) as shown in Table 2. The calorific value of the sponge seems to be independent from its symbiotic fraction. In fact, although the cyanobacteria population, measured as chl-*a* values, reduces progressively with depth (BAVESTRELLO *et al.*, 1994), the calorific values remain relatively constant. Moreover, very little differences are found between symbiocortex and medulla at all depths, conforming the low contribute of the symbionts to the global energetic value of the sponge.

During the whole life cycle of *P. atromaculata* (24 months), considering that it can reach a maximum length of 100 mm and assuming a constant daily ingestion rate in individual between 50 and 100 mm in length, it needs about 500 cm² of *Petrosia*, equivalent to 46000 cal, about 14000 of which lost as heat. This amount fits with a sponge of 20-24 cm of diameter. It follows that one specimen of this nudibranch needs a middle size

Petrosia for its subsistence during the whole life cycle.

The frequency of *Petrosia* in the Mediterranean hard bottom communities and its ability to regenerate the symbiocortex, avoiding necrosis, suggest that the food requirement is not a constraint for *P. atromaculata* population. Since this mollusc seems to have strong chemical defensive systems (CIMINO *et al.*, 1980, 1983; AVILA, 1995) and no specific predator is known, its density must be controlled by other factors, probably during the larval life, where predation may be intense even if not selective.

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